

# S P E C I F I C A T I O N

## SYSTEMS AND METHODS FOR PROVIDING POSITION INFORMATION USING A WIRELESS COMMUNICATION DEVICE

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

[001] The invention relates generally to wireless communication and more particularly to systems and methods for obtaining position information using a wireless communication device.

#### 2. Background

[002] A traditional Global Positioning Technology (GPS) receiver receives and processes specially coded satellite communication signals. The Satellite signals are generated from an array of satellites that comprise the GPS system. Nominally, this array consists of 24 satellites arranged in various orbits such that between 5 and 8 satellites are visible from any point on earth. GPS receivers convert the satellite signals into position, velocity, and time estimates. Four satellites are required to compute the three position dimensions (x,y,z) as well as the time.

[003] Today, GPS capability is frequently added to wireless communication handsets. Unfortunately, the GPS signals operate at different frequencies than those used for typical wireless communication. GPS signals operate in the 1500MHz band, while in the U.S., wireless communication systems generally operate in the 800MHz and 1900Mhz bands. As a result, the GPS signals cannot be received using a wireless communication handset's antenna and receiver. Therefore, in order to add GPS capability to a handset, a separate antenna and receiver must be included in the handset.

[004] There are generally two conventional ways to implement GPS capabilities in a wireless handset. The first is illustrated by exemplary communication system 100 in figure 1. System 100 comprises a wireless handset 106 in communication over communication channel 108 with a base station 110. Base station 110 is, for example, at the center of a communication cell within a Wireless-Wide Area Network (W-WAN). Thus, handset 106 includes the requisite antenna and transceiver for communicating over communication channel 108. Again, communication channel 108 typically comprises signals in the 800MHZ and/or 1900Mhz range.

[005] Additionally, handset 106 is in communication with GPS satellites 102 over satellite communication channels 104. Thus, handset 106 also includes an antenna and associated GPS circuitry for receiving the satellite signals over satellite communication channels 104. In this implementation, the GPS circuitry decodes the satellite signals. The satellite signals are then sent to a Position Determination Entity (PDE) (112) interfaced with base station 110. PDE 112 determines the position of handset 106 from the decoded satellite signals and this information is transmitted back to handset 106, where it can, for example, be displayed on handset 106.

[006] Thus, for example, if the subscriber wants to know his position, he can input a position request into handset 106. Handset 106 then acquires satellite signal information over satellite communication channels 104 using the GPS circuitry. The GPS circuitry decodes the satellite signals and handset 106 transmits the decoded signals to PDE 112 over communication channel 108. PDE 112 generates the position information from the decoded signals and transmits a position back to handset 106, where it is displayed to the subscriber on handset 106. PDE 112 can also be used to provide

handset 106 with Access assist (AA) and sensitivity assist (SA) information to help handset 106 acquire satellites 102 over satellite communication channels 104.

[007] By incorporating the GPS processing capabilities in PDE 112 instead of handset 106, the cost, complexity, and size of handset 106 can be reduced while offering enhanced GPS performance due to the greater computational power of the PDE. Since there is constant pressure to reduce the cost, complexity, and size of wireless communication handsets, this networked based approach has distinct advantages. There are, however, important disadvantages. First, for example, the network based approach increases the network traffic in system 100, which reduces system capacity, meaning fewer users can use the system. Second, the GPS capability only works when handset 106 is in range of system 100.

[008] Figure 2 illustrates a logical block diagram of an exemplary wireless handset 200 that can be used to illustrate a second way to implement GPS capabilities in a wireless handset, which overcomes the disadvantages of the implementation illustrated in figure 1. Handset 200 comprises an antenna 220 and wireless communication transceiver 224 configured to transmit and receive wireless communication signals, such as those that would be communicated over communication channel 108 in figure 1. Wireless communication transceiver 224 comprises receiver 216, which is configured to receive wireless communication signals from antenna 220, filter and amplify them, and then send them to demodulator 218. Demodulator 218 demodulates the received signal in order to generate a baseband information signal that is sent to modem 212. Historically, a modem comprised a modulator and a demodulator. However, a common definition for a modem is simply a modulator coupled with some signal processing functions. Within

this patent, a modem is defined as a modulator coupled with a processor. Transceiver 224 also includes transmitter 214, which is configured to transmit wireless communication signals via antenna 220 generated by Modem 212.

[009] Typically, demodulator 218 comprises two stages: the first stage steps the frequency of a received signal down from a Radio Frequency (RF), used for transmitting signals over channel 108, to an Intermediate Frequency (IF). The IF frequency signal is then stepped down, in the second stage of demodulator 218, to baseband.

[010] Modem 212 preferably includes various circuits for controlling the operation of handset 200 in general, and in particular for controlling communication using transceiver 224. Thus, Modem 212 can include various analog-to-digital (A/D) and digital-to-analog (D/A) converters, processors, Digital Signal Processors (DSPs), Vocoder, and peripheral control circuits as required by a particular handset 200. Alternatively, some or all of these circuits can be included in handset 200 as stand alone components or as components incorporated into the various components of transceiver 224.

[011] In addition, handset 200 includes GPS processor 208 configured to process GPS signals received via antenna 202, which are filtered and amplified in GPS receiver 204 and demodulated in GPS demodulator 206. Thus, GPS processor 208 can generate position information when requested without the aid of a network based position determination. Accordingly, the implementation of figure 2 overcomes the problems associated with network based position determination, such as increased traffic and a limited operating range. But, as mentioned, including a full GPS receiver in handset 200 drives up the cost, complexity, and size of handset 200 and can also have other negative

effects such as reduced battery lifetime. As such, neither of the conventional solutions for incorporating GPS into a wireless communication handset is satisfactory.

## SUMMARY OF THE INVENTION

[012] In order to overcome the problems associated with conventional approaches for incorporating GPS into a wireless handset, the systems and methods for providing position information using a wireless communication device reuse various components of a wireless handset in order to reduce the overhead associated with including a GPS receiver. In particular, systems and methods are provided for configuring a wireless communication handset to use a single processor to process both GPS signals and wireless communication signals such that the handset can act as a standalone GPS receiver, without unduly increasing the size, complexity, and cost of the handset. Additional embodiments also reuse various other handset components to further decrease size, complexity, and cost, thus extending the benefits of the system and methods described herein.

[013] Other aspects, advantages, and novel features of the invention will become apparent from the following Detailed Description of Preferred Embodiments, when considered in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

[014] Preferred embodiments of the present inventions taught herein are illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings, in which:

[015] Figure 1 is a diagram illustrating an exemplary wireless communication network comprising network based GPS capability;

[016] Figure 2 is a logical block diagram of an exemplary wireless communication handset that incorporates a full GPS navigational system;

[017] Figure 3 is a logical block diagram of one example embodiment of a wireless communication handset that incorporates GPS capability in accordance with the invention;

[018] Figure 4 is a logical block diagram illustrating another example embodiment of a wireless communication handset that incorporates GPS capability in accordance with the invention; and

[019] Figure 5 is a flow chart illustrating one example process for determining the position of the wireless handset of figure 3 or figure 4.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[020] Figure 3 illustrates a logical block diagram of one example embodiment of a handset 300 that incorporates GPS capabilities using a single processor to process both GPS signals and wireless communication signals in accordance with the systems and methods described herein. Thus, handset 300 comprises an antenna 302 for receiving GPS signals. The received GPS signals can then be passed to a GPS receiver 304, where they can be filtered and amplified before being sent to GPS demodulator 306. The demodulated GPS signals are then sent to Modem 314 to be processed.

[021] Modem 314 preferably comprises the circuits to interface with wireless communication transceiver 312. Thus, Modem 314 preferably controls communication

via antenna 318 using transceiver 320, which means that Modem 314 generates signals to be transmitted by transmitter 312 and processes signals filtered and amplified by receiver 310 and demodulated by demodulator 308. In addition, however, Modem 314 includes the processing capability to generate position, velocity, and time estimates, for example, from the GPS signals received by antenna 302. Modem 314 can then, for example, be instructed to display such information on display 322 included in handset 300.

[022] Preferably, a memory 316 is included in handset 300 to store instructions used by Modem 314 to control the operation of handset 300 generally, to process the GPS signals, and to control communication using transceiver 320. Memory 316 can comprise a single memory device or multiple memory devices as required. Memory 316 preferably comprises a primary non-volatile memory for storing instructions for use by Modem 314 and for storing information used by Modem 314 in executing the instructions. Additionally, memory 316 preferably includes a secondary memory used to store temporary information used by Modem 316. Thus, by storing the appropriate instructions and information in memory 316, Modem 314 can act as a GPS processor.

[023] Accordingly, handset 300 can be configured to act as a GPS receiver independently of the presence of network coverage. Moreover, the cost and complexity of handset 300 is not increased as significantly as it would be if a complete standalone GPS navigational system were included in handset 300. Thus, the embodiment illustrated in Figure 3 overcomes the problems associated with traditional approaches by incorporating GPS capability into handset 300 through the reuse of existing components. Moreover, the concept of component reuse can be extended even further to achieve

greater reductions in size, complexity, and cost, while still incorporating full GPS capability into a handset.

[024] Figure 4 illustrates a logical block diagram of another example embodiment of a handset configured in accordance with the systems and methods described herein in which more extensive reuse of components is implemented so as to further reduce size, complexity and cost. First, handset 400 uses a single antenna 402 to receive both GPS and wireless communication signals. Systems and methods for using a single antenna to receive both GPS and wireless communication signals are described more fully in U.S. Patent Application Serial No. 09/898,269, entitled "System and Methods for Providing a GPS Enabled Antenna," filed July 3, 2001, which is fully incorporated herein by reference. Importantly, the systems and methods described in Patent Application Serial No. 09/898,269 allow a handset to use a single antenna without degrading the GPS or wireless communication performance of handset 400.

[025] As explained in Patent Application Serial No. 09/898,269, specifically with reference to figures 2A, 2B, 4, 8 and 9 each of which are incorporated herein by reference as are the corresponding descriptions, a diplexer, a duplexer, a passive combiner or switch 404 is used to direct signals received by antenna 402 to the appropriate receive circuitry. Thus, when antenna 402 receives GPS signals, diplexer 404 will direct them to GPS LNA 408 where they can be amplified, for example. Typically, the GPS signals will also be filtered by a filter (not shown) in the GPS signal path. If, on the other hand, antenna 402 receives wireless communication signals, then diplexer 404 can direct these to duplexer 406. Duplexer 406 allows a transmitter (not shown) and receiver to be simultaneously connected to antenna 402 while maintaining



sufficient isolation between the two to ensure that they do not interfere with each other. The principles of duplexer operation are well known. Thus, wireless communication signals received by antenna 402 can be directed through diplexer 404 and duplexer 406 to PCS LNA 410, where they can, for example, be amplified. A PCS LNA 410 is shown by way of example only. Other wireless communication signal amplifiers could also be used.

[026] GPS LNA 408 and PCS LNA 410 can then send the signals to separate demodulators as explained in relation to handset 300 in figure 3. But further reuse can be achieved by using the same demodulator to demodulate both the wireless communication and GPS signals. Systems and methods for using a single demodulator for both GPS and wireless communication signals are described more fully in U.S. Patent Application Serial No. 09/975,124, entitled "Mixer and IF filter for GPS Systems," filed October 8, 2001, which is fully incorporated herein by reference. Again, as explained in Patent Application Serial No. 09/975,124, specifically, for example, with reference to figures 1 and 3 each of which are incorporated herein by reference as are the corresponding descriptions, a diplexer, duplexer, passive combiner or switch 412 is used to direct signals from GPS LNA 408 or PCS LNA 410 to mixer 414. Mixer 414 is then configured to mix the GPS signals or the wireless communication signals with a signal of an appropriate frequency in order to remove the RF carrier associated with each signal. As will be understood, PCS signals are discussed here by way of example only. Accordingly, the PCS LNA 410 is shown by way of example only.

[027] Typically, a Voltage Controlled Oscillator (VCO) is used to generate the appropriate mixing signal. Thus, such a VCO would need to be programmable so as to generate a signal of the correct frequency depending on which receiver, 408 or 410, is

connected with mixer 414. A dual band VCO 66 that is capable of such programming is fully described in Patent Application Serial No. 09/975,124. It will be understood by those of skill in the art that the devices and methods described herein for reusing a modem to process GPS signals and PCS or cellular CDMA signals could also be used to process GPS signals and signals in other bands, such as, for example, CDMA2000 signals.

[028] Preferably, mixer 414 mixes the signals down to IF signals, which can be further processed in IF block 422. IF block 422 can, for example, filter the IF signals and then mix them down to baseband. IF block 422 can also include A/D converts to convert the baseband signals for further processing by Modem 424. Again, Modem 424 is configured to process both the GPS signals and the wireless communication signals as described with relation to figure 3.

[029] Accordingly, even further reduction in size, complexity, and cost is achieved through the reuse of various components in handset 400, while still providing full GPS capability even when handset 400 is out of range of the network. Moreover, because the GPS capabilities are not network based, GPS capability is provided without increasing network traffic.

[030] As illustrated in figure 4, handset 400 can be configured to receive a plurality of wireless communication signals. For example, handset 400 can be configured for dual band, 800MHz and 1900Mhz, operation. In which case, handset 400 includes a second duplexer 416 for connecting a second wireless communication transmitter (not shown) and cellular CDMA LNA 418 to antenna 402. Cellular CDMA LNA 418 is then interfaced with a second mixer 420. Since the GPS signals operate in the 1500GHz band,

mixer 414 is preferably configured to receive the 1900GHz wireless communication signals, because they are closer in frequency to the GPS signals. This makes it easier to configure the various components to handle both the GPS signals and the wireless communication signals. Reuse of a single antenna and of mixers in handsets configured to receive a plurality of wireless communication signals is, however, more fully explained in Patent Application Serial No. 09/898,269 (Applicant Docket No. UTL-00081) and Patent Application Serial No. 09/975,124 (Applicant Docket No. UTL-00036).

[031] Even though a handset configured in accordance with the systems and methods described herein can function as an independent GPS device, such a handset can also use GPS network resources if they are available. For example, if handset 300 is operating within the network, then it can periodically receive AA and SA information from the network, e.g., PDE 112. The AA and SA information can then be stored in memory 316 and used by Modem 314 to determine the position of handset 300. Alternatively, handset 300 can just use the network resources if they are available as described in relation to figure 1.

[032] Figure 5 illustrates a flow chart of a process whereby a handset, such as handset 300, can use network GPS resources. First, handset 300 receives a request for position information in step 502. For example, the subscriber may input a request to handset 300 through a user interface (not shown). Then, in step 504, handset 300 determines if network assisted GPS capabilities are available. If they are available, then in step 506, the network based GPS capabilities are used to determine the position of handset 300.

[033] In the event that network based GPS capabilities are not available, then in step 508 handset 300 deactivates wireless communication transceiver 312 and the associated processing capabilities and activates the GPS capabilities. This can, for example, comprise activating GPS receiver 304 and GPS demodulator 306. Alternatively, step 508 can, for example, include controlling switches 404 and 412 so that the GPS circuitry is properly interfaced with antenna 402 and mixer 414. Moreover, step 508 can require that the appropriate GPS instructions be loaded into a primary or active portion of memory 316.

[034] In step 512, GPS signals are captured and eventually sent to Modem 314. Then in step 514, Modem 314 can, for example, determine the position of handset 300 from the received GPS signals. Finally, the position can be displayed to the subscriber on display 322. Additionally in cases of an emergency, the location of the emergency event can be stored within the phone and thence relayed to the emergency services via an E911 call once phone coverage is available. This latter function is very useful when an emergency occurs outside normal phone coverage areas, but a person is still able to travel and summon assistance.

[035] The embodiments described above illustrate that the systems and methods for providing position information using a wireless communication device overcome the problems associated with conventional approaches. Thus, the systems and methods described herein allow GPS capability to be included in a handset, while reducing network traffic as well as the size, complexity and cost of the handset.

[036] Further, while embodiments and implementations of the invention have been shown and described, it should be apparent that many more embodiments and

implementations are within the scope of the invention. For example, it will be apparent that the systems and methods described herein are not limited to the specific handset architectures shown and described. Rather the architectures described above and illustrated in the figures are by way of example. Additionally, the systems and methods described herein are not limited to wireless communication handsets. It will be apparent that any wireless communication device into which GPS capability is to be integrated can benefit from the systems and methods described. Accordingly, the invention is not to be restricted, except in light of the claims and their equivalents.

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